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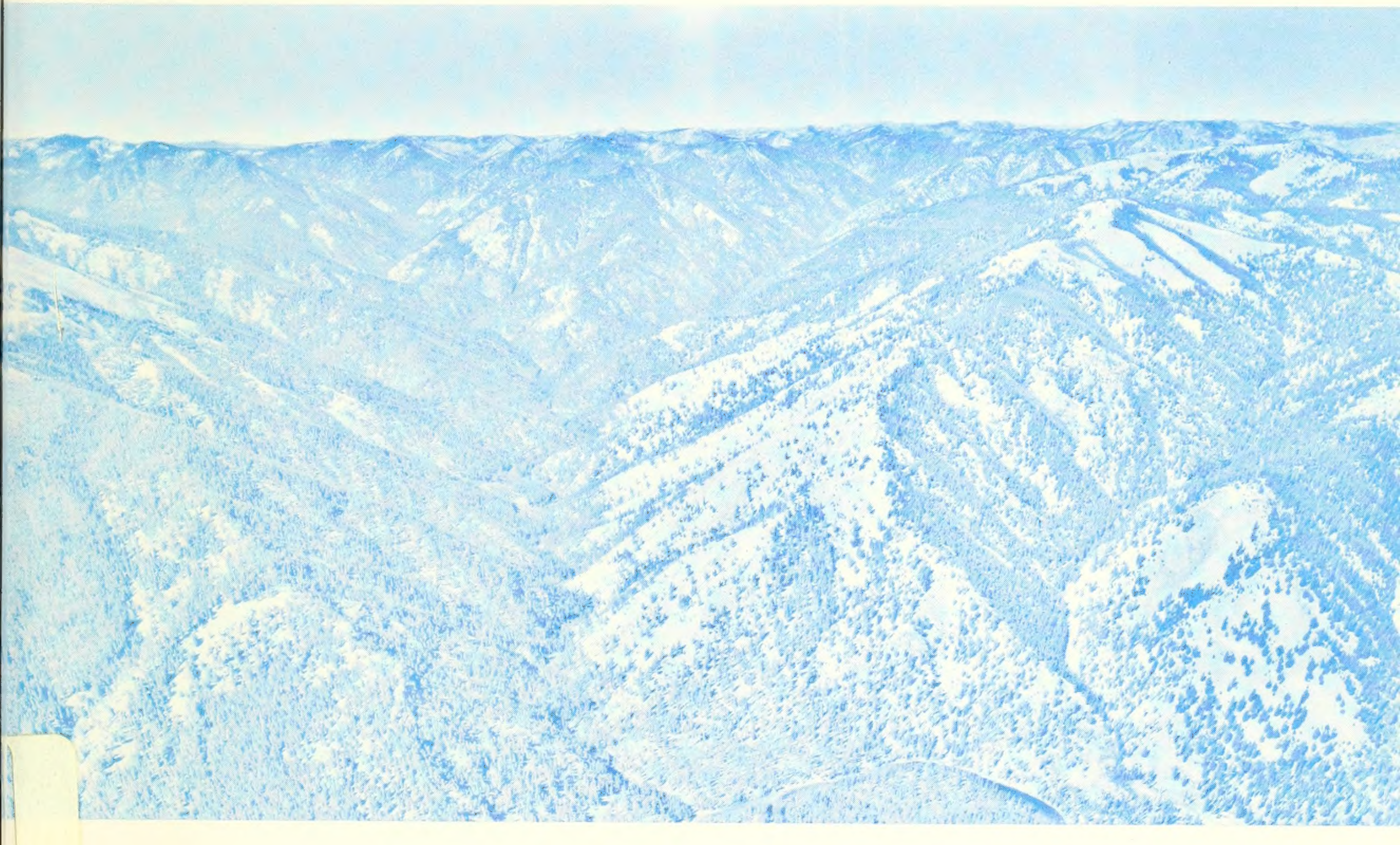
Walter F. Megahan and Walter J. Kidd



USDA Forest Service Research Paper INT-123, 1972
INTERMOUNTAIN FOREST AND RANGE
EXPERIMENT STATION
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Cover Photo:--Typical midelevation stream-cut topography in the Idaho Batholith.

USDA Forest Service
Research Paper INT-123
May 1972

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ABSTRACT

Effects of logging road construction on sediment production rates were studied on small, ephemeral drainages in the Idaho Batholith, a large area of granitic rock characterized by steep slopes and highly erodible soils. For the 6-year study period, about 30 percent of the total accelerated sediment production from roads was caused by surface erosion; the remainder resulted from mass erosion. Surface erosion on roads decreased rapidly with time after extremely high initial rates. A mass failure of a road fill slope occurred about 4 years after construction, when surface erosion had fallen to a low rate. The sediment production rate attributed to erosion within the area disturbed by road construction averaged 770 times greater (220 because of surface erosion and 550 because of mass erosion) than that for similar, undisturbed lands in the vicinity.

Results suggest three guides to use in the control of surface erosion on roads and subsequent downslope sediment movement in the Idaho Batholith: (a) Apply erosion control measures immediately after road construction for maximum effectiveness; (b) ensure that treatments protect the soil surface until vegetation becomes established; (c) take advantage of downslope barriers (logs, branches, etc.) to effectively delay and reduce the downslope movement of sediment.

INTRODUCTION

There is considerable evidence that logging roads are the primary source of accelerated erosion and sedimentation on logged watersheds. Packer (1967) concluded:

> Of man's activities that disturb vegetation and soil in forests, none are greater precursors of sediment damage to water quality than the construction of roads.

Numerous others have substantiated Packer's conclusion (Anderson 1954; Reinhart and others 1963; Haupt and Kidd 1965; and Leaf 1966).

Logging road construction is particularly damaging in highly erodible areas, such as the 16,000-square-mile Idaho Batholith (fig. 1), which is characterized by steep topography and shallow, coarse-textured soils overlying granitic bedrock. Soils derived from parent material of this type were the most erodible to be found in Oregon and northern California (Anderson 1954; and André and Anderson 1961). Recognition of such unstable soil conditions on steep batholith lands led to the initiation of the Zena Creek logging study in 1959 (Craddock 1967). The study, which was a cooperative effort carried out by the Intermountain Region and the Intermountain Station of the USDA Forest Service, was conducted near the confluence of the South Fork of the Salmon and the Secesh Rivers in the mountains of central Idaho.

Part of the research effort included a study to evaluate the effects of jammer and skyline logging systems on erosion and sedimentation in the Deep Creek drainage (Megahan and Kidd In press). The purpose of this report is to explore types and rates of change of the road erosion that occurred during the Deep Creek study.

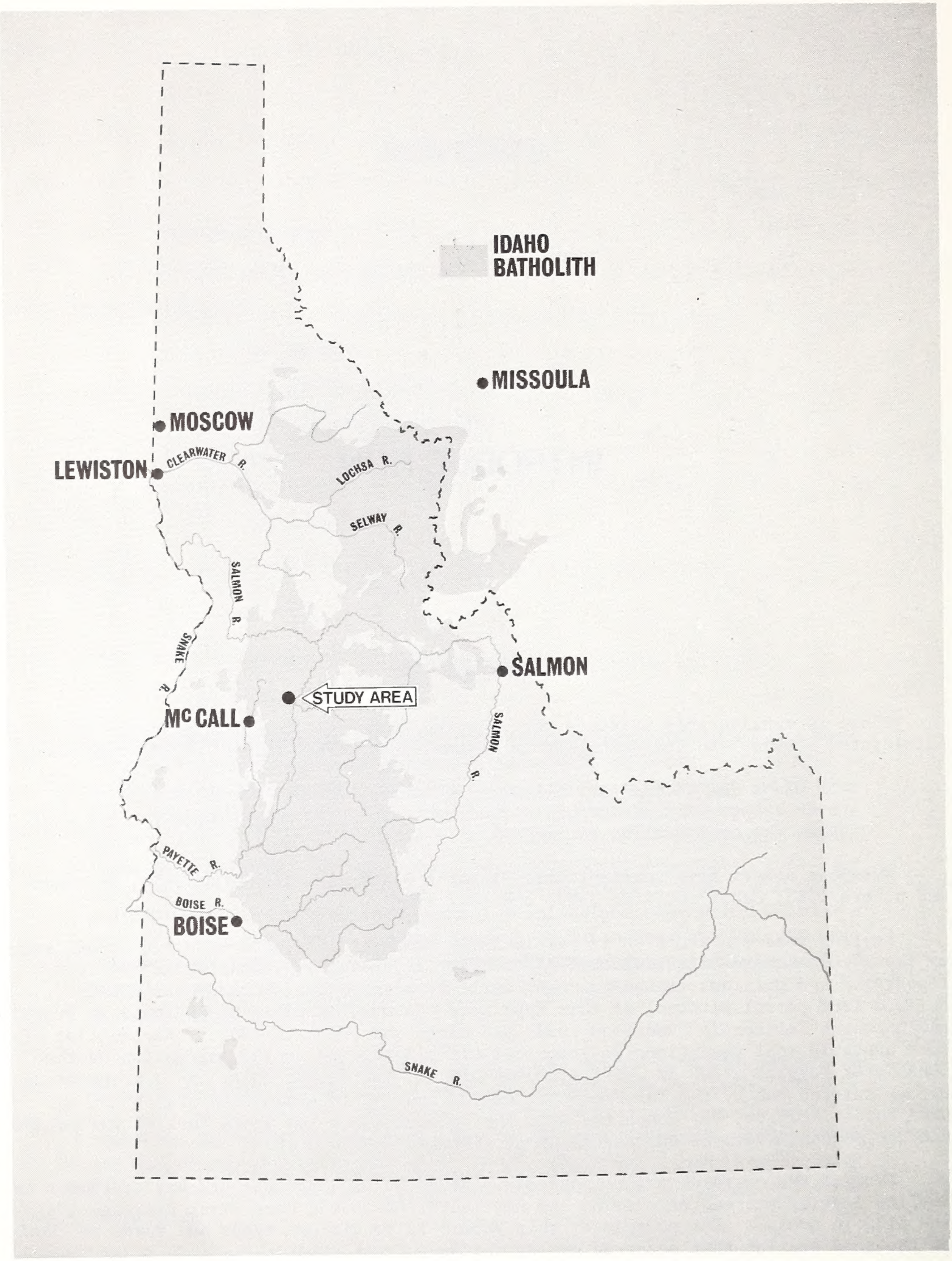

Figure 1.--Location map of the Idaho Batholith and the study area.

STUDY AREA AND METHODS

The study area is within the confines of the Zena Creek logging study area near the head of the Deep Creek drainage, a tributary to the Secesh River. Three contiguous, ephemeral drainages comprise the 10-acre area (fig. 2). Annual precipitation at the study area averages 28.3 inches, of which about 60 percent occurs as snow.

The dominant tree species are ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco). The coarse, loamy sand soils are derived from quartz monzonite bedrock and are poorly developed, exhibiting only A and C horizons. Additional descriptive data are summarized in table 1.

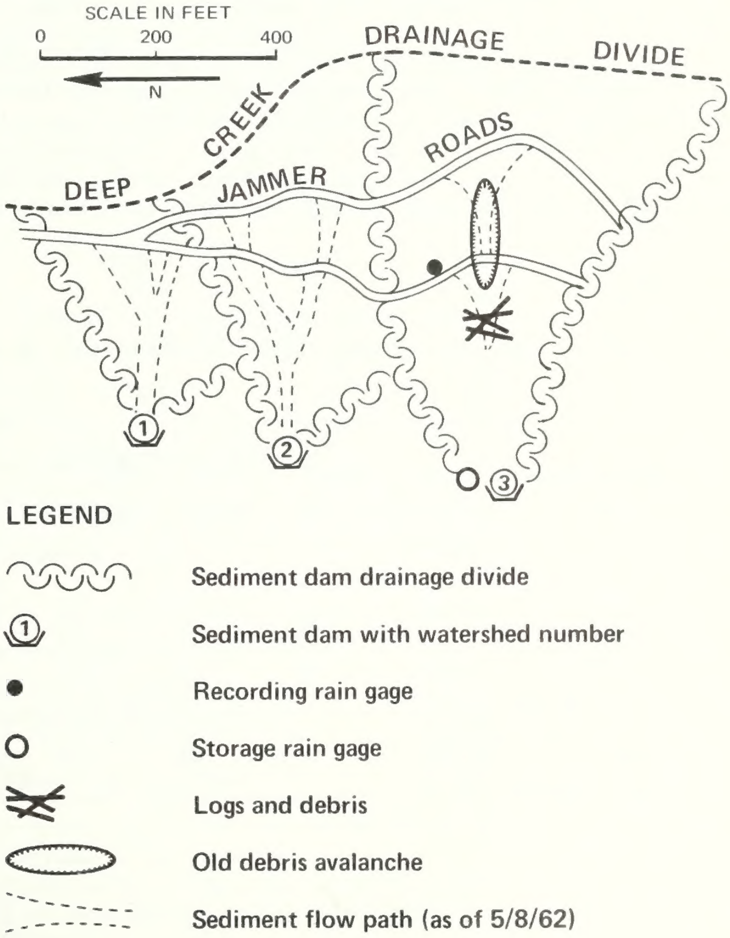

Figure 2.--Schematic map of the study watersheds.

Table 1.--*Descriptive data for watersheds in the Deep Creek study area*

Characteristic	Watershed No. 1	2	3
Mean side slope gradient (percent)	74	65	71
Channel gradient (percent)	70	63	61
Watershed aspect (degrees azimuth)	274	285	270
Mean soil depth (inches)	16	22	22

Sediment movement in the study area is almost exclusively bedload because of the extremely coarse texture of the soil and parent materials; consequently, small dams were used to obtain sediment yields. Data from the sediment dams were collected twice a year--following the snowmelt period (about June 1); and near the end of the water year (about September 30). Accumulations of sediment behind dams were surveyed, using a grid of closely spaced cross sections, beginning on November 1, 1960.

Jammer roads totaling about 0.36 mile in length were built on the three watersheds during October 1961; standard sidecast construction practices were used (table 2). From October 25, 1962, to November 14, 1962, approximately 80 percent of the commercial timber was removed from the study area. Standard postlogging erosion control measures, including water bars and grass seeding, were installed on the jammer roads. Postlogging measurements of sediment production were continued on schedule until September 21, 1967.

Table 2.--*Jammer road construction on the study watersheds*

Watershed No.	Road length	Area disturbed: Road tread	Fill slope	Cut slope	Total	Watershed area	Percent watershed disturbed
	Feet	- - - - - - - - -	- *Acres*-	- - - - -	- - - - -	- - - - -	*Percent*
1	420	0.21	0.07	0.15	0.43	1.80	24
2	568	.28	.22	.14	.64	3.50	18
3	904	.38	.39	.25	1.02	4.70	22
Total	1,892	.87	.68	.54	2.09	10.00	21

RESULTS

The amount of sediment accumulated in the dams that could be attributed solely to road erosion was determined by comparing data on the three watersheds to data of the same type collected on five contiguous and similar but unroaded watersheds (Megahan and Kidd In press). Sediment yield data for individual watersheds shown in table 3 represent material eroded from the road prism by surface erosion unless otherwise noted. Surface erosion can be described as movement of individual soil particles; it includes both sheet and gully erosion.

Table 3.--*Sediment yields from road erosion in the Deep Creek study area*

Measurement period	Elapsed time	Watershed 1	Watershed 2	Watershed 3	Total	Average
	Days		*Cubic feet*			*Tons/day/mi.^{2} of road*
11/60 - 6/61	232	0.0	0.0	0.0	0.0	0.0
6/61 - 11/61	134	.0	.0	.0	.0	.0
11/61 - 6/62[1]	238	778.3	1,089.0	14.7	1,882.0	109.0
6/62 - 10/62	120	67.6	62.8	9.1	139.5	16.0
10/62 - 11/62	20	--	Period of logging on study watersheds			--
11/62 - 5/63	195	.0	83.3	68.3	151.6	10.7
5/63 - 9/63	113	.0	73.0	.0	73.0	7.8
9/63 - 5/64	251	.0	1.8	9.7	11.5	.6
5/64 - 10/64	128	.0	.0	.0	.0	.0
10/64 - 6/65[2]	252	.0	40.4	--	40.4	4.4
6/65 - 9/65	105	.0	9.4	--	9.4	2.7
9/65 - 6/66	258	2.2	60.4	--	62.6	6.5
6/66 - 9/66	100	.0	.0	--	.0	.0
9/66 - 5/67	250	.0	11.3	--	11.3	1.2
5/67 - 9/67	120	.2	32.0	--	32.2	7.3

Total sediment accumulation from surface erosion = 2,413.5 cubic feet
Total sediment accumulation from mass erosion[2] = 6,030.0 cubic feet

Total sediment accumulation from road erosion = 8,443.5 cubic feet

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[1] Road construction completed during this period.

[2] Dam number 3 irreparably destroyed by a road fill failure (mass erosion) on 4/23/65. Field measurements at the failure site indicated 6,030 cubic feet of material moved down the channel.

Figure 3.--Downslope sediment movement resulting from road erosion above. Sediment is easily traced because of the light color, coarse texture, and uniform gradation of the materials.

Sediment production during the first time period after construction was extremely high on Watersheds 1 and 2 but decreased rapidly in subsequent periods. However, this didn't occur on Watershed 3. A survey of sediment flow was conducted May 8, 1962, to examine this anomalous behavior on Watershed 3. The downslope movement of sediment on each watershed was mapped from its source to its downslope terminus. This is easily done because of the light color, the coarse texture, and the uniform gradation of the eroded material in this area (fig. 3). The cause of the limited sediment production on Watershed 3 was readily apparent; a barrier of logs and debris in the drainage bottom was catching the material en route (fig. 2).

Sediment flow phenomena have been noted elsewhere and research has shown that natural and/or artificial barriers delay and reduce coarse sediment movement downslope (Trimble and Sartz 1957; Haupt 1959; Packer and Christensen 1964).

Additional erratic behavior was noted on Watershed 3. A natural landslide scarp existed on this watershed prior to road construction. This type of slide, classified as a debris avalanche (National Research Council, Highway Research Board 1958), is characterized by rapid downslope movement of soil and rock material having varying

Figure 4.--View of the lower jammer road in Watershed 3, where the debris avalanche originated because of a road fill failure.

Figure 5.--The debris avalanche scoured the bottom of Watershed 3 to bedrock. The slide obliterated the sediment dam (formerly in the channel bottom) and splashed mud on top of the storage rain gage tower (see arrow).

water contents. Debris avalanches usually leave a discernible elongated scar to bedrock at the slide origin and often exhibit a characteristic downslope slide path. The lower jammer road in Watershed 3 was constructed through the old slide area without taking special precautions (fig. 2). In April 1965, a combination of rainfall and snowmelt generated a massive failure of the road fill material at the site of the old landslide (fig. 4). The slide scoured the entire length of the channel to bedrock in Watershed 3 and destroyed the sediment dam (fig. 5). Postslide measurements indicated that approximately 6,030 cubic feet of sediment moved down the channel.

Total Erosion

The total surface erosion for the three watersheds for each sampling period is shown in table 3. Data for all three watersheds (before sediment dam 3 was destroyed) are included in this total because natural sediment barriers are commonly found on slopes in this vicinity. Surface erosion for the entire 6-year study period totaled 2,413.5 cubic feet. The 1965 mass erosion event amounted to an additional 6,030 cubic feet of sediment, which, added to the surface erosion, totaled 8,443.5 cubic feet of erosion from roads for the 6-year study period. Thus, about 30 percent of the soil loss could be attributed to surface erosion and the remainder to mass erosion. Actually, the total percentage of surface erosion might be greater by a few percent because some erosion undoubtedly continued in Watershed 3 after the destruction of the sediment dam.

The effects of road construction and logging on sediment movement can best be appreciated by comparing the rates generated by these uses to the rates for undisturbed lands. Sediment dams were used to determine sediment yields on undisturbed, perennial watersheds in the immediate vicinity. These included the Oompaul, Hamilton, Tailholt, and Circle End drainages, which are 740, 460, 1,625, and 930 acres in size, respectively.

During the 6-year study period, sediment data were collected on one or more of these watersheds and included the effects of natural landslides within the drainages. For the study period, the average sedimentation rate on the undisturbed watersheds (weighted for drainage area) was 0.07 ton/mi.^{2}/day. This rate is not unreasonable for undisturbed forested lands in the Rocky Mountains; for example, Leaf (1966) reports average sediment production of 0.02 ton/mi.^{2}/day for watersheds in Colorado.

Using this average sediment production rate of 0.07 ton/mi.^{2}/day for undisturbed lands, we calculated that about 10.9 cubic feet of sediment would have been collected in the three sediment dams from the area disturbed by roads during the 6-year study period if the roads hadn't been built. Comparing this to actual sediment production from road erosion for the 6-year study period, we find that sediment yields increased approximately 770 times following road construction (220 times because of accelerated surface erosion *plus* 550 times because of accelerated mass erosion)!

Time Trends in Surface Erosion

The average annual sediment production from surface erosion on roads is an informative way of evaluating time trends (table 4). Note that about 84 percent of the total sediment for the 6-year study period was produced during the first year after construction. By the end of the second year, the total sediment production had risen to over 93 percent.

A histogram of the average sediment production data for individual measurement periods is an even more enlightening way of evaluating time trends (fig. 6). A second y axis on the right side of the figure indicates how many times sediment production from roads exceeds that from similar lands that are undisturbed. Note that sediment production during the first time period after construction averaged 109 tons per day per square mile of road--about 1,560 times greater than sediment production from similar lands that are undisturbed. Note also that this high initial rate decreases rapidly during subsequent measurement periods. As noted previously, sediment production rates resulting from surface erosion averaged about 220 times greater than the rates for undisturbed lands during the 6-year study period.

Table 4.--*Sediment production due to surface erosion on roads by years after construction*

Year	Sediment production	Percent of total	Accumulated percent
	Cubic feet		
1961-62	2,021.5	83.8	83.8
1962-63	226.6	9.4	93.2
1963-64	14.3	0.6	93.8
1964-65	54.2	2.2	96.0
1965-66	55.4	2.3	98.3
1966-67	41.5	1.7	100.0
Total	2,413.5	100.0	

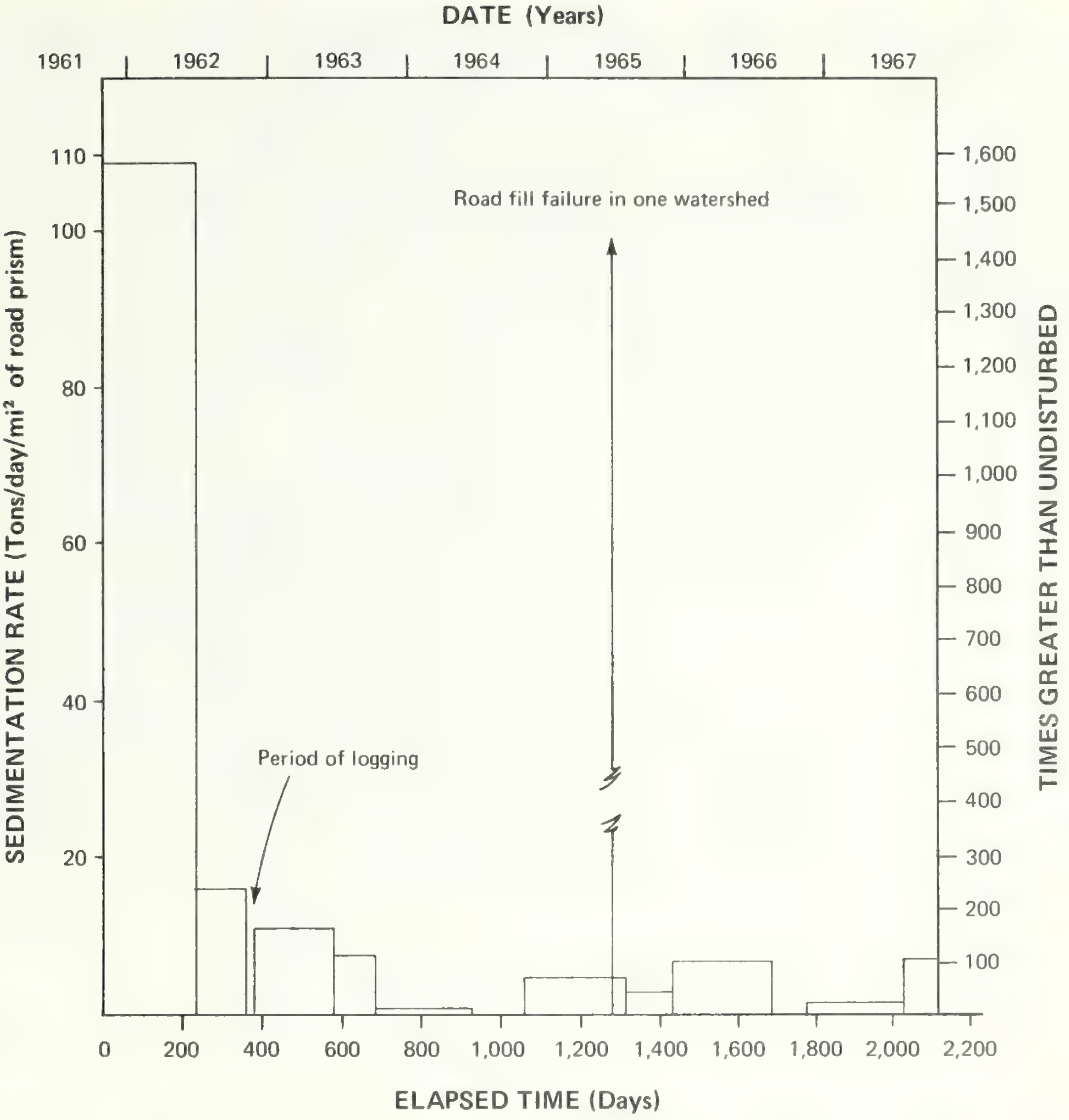

Figure 6.--Sediment production over time from surface erosion on jammer roads.

Intuitively, one can visualize how bare, unprotected material in a road prism could be subject to extremely high surface erosion immediately after construction. However, in time, the more erodible materials are removed and vegetation and litter begin to accumulate; this causes a decrease in surface erosion rates. Research data elsewhere suggest time trends in sediment production from road erosion (Rice and Wallis 1962; Reinhart and others 1963; Haupt and Kidd 1965; Vice and others 1969; Fredriksen 1970). In our study, sediment production rates had decreased progressively to zero prior to the 1964-65 measurement period. In subsequent measurement periods these ratios exhibited considerable fluctuations; ranging from zero to about 100 times greater in roaded areas than on undisturbed lands (fig. 6). Recent studies (Anderson

Figure 7.--Granitic rocks in the Idaho Batholith exhibit various degrees of weathering. Road cuts in the more highly weathered types continue to supply sediment for years.

1970) indicate that sediment production increases greatly after a major storm event such as occurred in December 1964 in California. The same storm hit Deep Creek and, coupled with the April 1965 event, apparently caused the increases found in Deep Creek. Anderson reports that high poststorm sedimentation tends to decrease with time; however, this trend was not detected in Deep Creek for the measurement periods following the April 1965 storm.

Actually it is doubtful that erosion on roads in the Idaho Batholith will permanently decrease within a reasonable time to the level that existed before disturbance. The road tread and steep cut slopes in the Deep Creek area are composed of weathered granitic bedrock that continues to disintegrate after exposure faster than natural stabilization can take place (fig. 7). The material resulting from bedrock disintegration is readily transported during subsequent runoff events. Similar bedrock conditions are found throughout much of the unglaciated portions of the Idaho Batholith.

DISCUSSION AND CONCLUSIONS

Total sediment production per unit area of road prism increased an average of 770 times for the 6-year study period. At present, the impact such an increase will have on the important downstream salmon spawning resources is undefined; however, there are indications that this level of impact is intolerable (Richards 1963). Short of forbidding all road construction, our findings emphasize the need for: (a) More careful planning to minimize the mileage of road construction, including consideration of logging systems that require fewer roads; and (b) diligent location, design, construction, and maintenance to minimize erosion on the roads that are built.

Surface erosion following road construction on steep, highly erodible batholith lands, such as those found in Deep Creek, decreases rapidly with time. About 85 percent of the erosion occurs during the first year after construction. This emphasizes that (a) measures to control surface erosion must be applied as soon after construction as possible to be effective; and (b) reseeding alone, as was carried out on Deep Creek, is not the complete answer because vegetation is slow to respond.

Observations suggest that most of the high initial surface erosion is actually the result of erosion on exposed road fills (fig. 8). Considerable data indicate that erosion on granitic road fills can be greatly reduced by stabilization measures such as the treatments listed in table 5. Note that erosion rates on granitic road fills can be reduced up to 99 percent by such stabilization treatments. The largest proportion of surface erosion occurs during the first year and is generally the result of erosion on fill slopes; therefore, it appears to be possible to greatly reduce sedimentation caused by surface erosion on roads using these fill slope stabilization treatments.

After about 3 years, the extremely high initial sediment yields in Deep Creek had dropped dramatically but still averaged about 50 times greater than did sediment production on undisturbed lands. The erosion control treatments on road fills listed in table 5 and water control measures on the road tread (e.g., culverts, etc.) should help to reduce high, long-term sedimentation rates. However, it is not likely that sediment yields will drop to the levels expected on undisturbed lands because the cut slopes remain active sediment sources and, at present, practical erosion control measures are not feasible.

Even though erosion is occurring within a road prism it need not necessarily increase sediment yields at some downstream point. Results of this study reinforce those of earlier studies that showed the effectiveness of barriers (e.g., down logs, branches, etc.) in inhibiting the downslope movement of coarse granitic sediments.

Major impacts can still occur from mass erosion after sedimentation from surface erosion has dropped to a low level and (for all practical purposes) a road is considered relatively stable. In Deep Creek, a single storm event resulted in a road fill failure that accounted for about 70 percent of the total sediment production for

Figure 8.--*Surface erosion on road fills constructed from granitic materials 1 year after construction.*

the entire 6-year study period. Fredriksen (1970) reported similar slides on roads in steep, unstable terrain in western Oregon. Major failures of this type are not related to surface erosion rates, but rather tend to occur during large climatic events on those areas where the potential exists.

As with surface erosion, much mass erosion of road fills can be avoided by careful location, design, construction, and maintenance measures. Gonsior and Gardner (1971) listed guidelines for this purpose based on studies of slope failures in the vicinity of the Zena Creek logging study.

Table 5.--*Erosion control on road fills in the Idaho Batholith*

Stabilization measures[1]	Road location	Percent change in erosion[2]	References
None (except seed + fertilizer)	Bogus Basin	+15	Bethlahmy and Kidd 1966[3]
Planted ponderosa pine	Deadwood River	-47	Unpublished data[4]
Wood-chip mulch	Bogus Basin	-61	Bethlahmy & Kidd 1966
Straw mulch	Zena Creek	-72	Ohlander 1964
Jute netting	Zena Creek	-93	Ohlander 1964
Asphalt - straw mulch	Zena Creek	-97	Ohlander 1964
Straw mulch + netting + planted ponderosa pine	Deadwood River	-98	Unpublished data[4]
Straw mulch + netting	Bogus Basin	-99	Bethlahmy and Kidd 1966

[1] All measures except trees include items shown + grass seed and fertilizers.

[2] As compared to untreated control plots.

[3] Erosion was increased by 15 percent, possibly by the method of applying seed and fertilizer.

[4] On file at the Station's Forestry Sciences Laboratory in Boise, Idaho.

REFERENCES

Anderson, H. W.
1954. Suspended sediment discharge as related to streamflow, topography, soil and use. Amer. Geophys. Union Trans. 35: 268-281.

Anderson, H. W.
1970. Principal components analysis of watershed variables affecting suspended sediment discharge after a major flood. Int. Assoc. Sci. Hydrol. Pub. 96: 404-416.

André, J. E., and H. W. Anderson
1961. Variation of soil erodibility with geology, geographic zone, elevation and vegetation type in northern California wildlands. J. Geophys. Res. 66: 3351-3358.

Bethlahmy, N., and W. J. Kidd, Jr.
1966. Controlling soil movement from steep road fills. U.S. Forest Serv. Res. Note INT-45, 4 p., illus. Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401.

Craddock, G. W.
1967. Zena Creek logging study evaluation report. 63 p., illus. U.S. Forest Serv. Intermountain Forest & Range Exp. Sta., Ogden, Utah 84401.

Fredriksen, R. L.
1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. U.S. Forest Serv. Res. Pap. PNW-104, 15 p., illus. Pacific Northwest Forest and Range Exp. Sta., Portland, Oregon 97208.

Gonsior, M. J., and R. B. Gardner
1971 Investigation of slope failures in the Idaho Batholith. USDA Forest Serv. Res. Pap. INT-97, 34 p., illus. Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401.

Haupt, H. F.
1959. A method for controlling sediment from logging roads. USDA Forest Serv., Intermountain Forest and Range Exp. Sta. Misc. Pub. 22, 22 p., illus. Ogden, Utah 84401.

Haupt, H. F., and W. J. Kidd, Jr.
1965. Good logging practices reduce sedimentation in central Idaho. J. Forest. 63: 664-670.

Leaf, C. F.
1966. Sediment yields from high mountain watersheds, central Colorado. U.S. Forest Serv. Res. Paper RM-23, 15 p., illus. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colorado 80521.

Megahan, W. F., and W. J. Kidd
In press. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. J. Forest.

National Research Council, Highway Research Board
1958. Landslides and engineering practice. Spec. Rep. 29, No. 21, 232 p.

Ohlander, C. A.
1964. Effects of rehabilitation treatments on the sediment production of granitic road materials. Master's Thesis, Colorado State Univ., 78 p.

Packer, Paul E.
1967. Forest treatment effects on water quality. Conf. Proc. on Forest Hydrology p. 687-699.

Packer, P. E., and G. F. Christensen
1964. Guides for controlling sediment from secondary logging roads. 42 p., illus. USDA Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401, and the Northern Region, Missoula, Mont., 59801.

Reinhart, K. G., A. R. Eschner, and G. R. Trimble, Jr.
1963. Effect on streamflow of four forest practices in the mountains of West Virginia. U.S. Forest Serv. Res. Pap. NE-1, 79 p., illus. Northeastern Forest Exp. Sta., Upper Darby, Pa., 19082.

Rice, R. M., and J. R. Wallis
1962. How a logging operation can affect streamflow. Forest Ind. 89:38-40.

Richards, M.
1963. Management of the chinook salmon fishery of the South Fork, Salmon River drainage. Idaho Wildlife Rev. 16(1):3-7.

Trimble, G. R., Jr., and R. S. Sartz
1957. How far from a stream should a logging road be located. J. Forest. 55: 339-341.

Vice, R. B., H. P. Guy, and G. E. Ferguson
1969. Sediment movement in an area of suburban highway construction, Scott Run Basin, Fairfax County, Virginia, 1961-64. Geol. Surv. Water-Supply Pap. 1591-E, 41 p., illus.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

Boise, Idaho
Bozeman, Montana (in cooperation with Montana State University)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with University of Montana)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)